Long Term Solution for Flood in Malala Lagoon, Hambantota

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Abstract

The lagoon systems play a major role in maintaining the balance of the organisms as well as the physical environment. The lagoon resources were misused due to unavailability of a proper management plan, environment pollution and lagoons converted into lands and polluted due to natural disasters. Therefore, the research was focused to find the vulnerable area and vulnerable communities to the flood; to carry out a scientific study to assess the hydrological, ecological, and biological impacts of the increased inflow into the lagoon; to study how the above problems affect the fishing community who depend on the lagoon for their livelihood , the farmers community who rely on paddy fields of vulnerable area and the other organisms who depend on the lagoon and surrounding area for their livelihoods; to find a long term solution for the flood in Malala and Embilikala lagoons, situated inside the Bundala conservation area of Hambanthota district. Considering the biological environment and the inundation affects the divert water directly to the sea from a canal through the reserved area is the best alternative to be acceptable by both farming and fishing communities and the environment.

Keywords: lagoons, floods, vulnerable, community, conservation

Introduction

Biosphere is a combination of lives in the small environmental units. Among the sub units in the biosphere the 'wetlands' received much importance because this wetland environment comprises of forests, deltas, estuaries, riverine, lakes, villu and lagoons. Among these sub units of the lagoon environmental system get an important place as it provides livelihood for the variety of plants and animals and acts as a source for the important needs of the human beings. The lagoons are known as the water bodies which are temporarily separated from the ocean for a long time by any of the disturbances and it is connected with the ocean in a certain period of a year (under the amendment of 1981 No 57 coast conservation act 12(5)of coastal zone management plan). Also the lagoons are known as the water bodies which are permanently separated by the ocean and connected with the ocean only in a period of a year (Source: Sri Lanka's Natural Resources- Mihikatha Organization).

The lagoon systems play a major role in maintaining the balance of the organisms as well as the physical environment. Present data indicates that Sri Lanka has mainly 89 lagoons in 36000 hectares of total area. But the worst situations near these lagoon systems are misused of resources because, unavailability of a proper management plan, natural lagoon environment pollution and lagoons converted into lands and polluted due to natural disasters (Matsuno *et.al*.,1998). After the tsunami in 2004, these adverse situations were increased and also there were involvement of government and other organizations in development and reconstruction. But due to lack of money, resource persons and other organizational conflicts influence on lagoon system was considerably low in Sri Lanka (Abeywickrama *et. al*., 2009).

Malala lagoon is located in Hambantota secretariat division of Hambantota district. Hambantota is a district situated in southern province which was affected from small and medium scale natural hazards in the recent past includes last event of tsunami, small earth quakes/trimmers, human-elephant conflict, drought, flood and landslides and some of natural disasters, like drought and flood occur regularly. Therefore, Hambantota is also indicated as a multi-hazard zone in Sri Lanka (fig.1). Malala-Embilikala lagoon system comprises of two water bodies, Malala and Embilikala which are connected to each other through a narrow canal. Malala lagoon is located close to the sea and it is open to the sea through nearly a 300 m wide mouth during the rainy season. During the dry periods, the mouth is closed by a naturally formed sand bar which is about two meters high from the lagoon water level. Embilikala is a low saline lagoon and is located nearly 1.7 km away to the Northeast of Malala connected through the canal, which is about a 40 m wide narrow canal that runs for about 3.1 km meandering between the two water bodies.

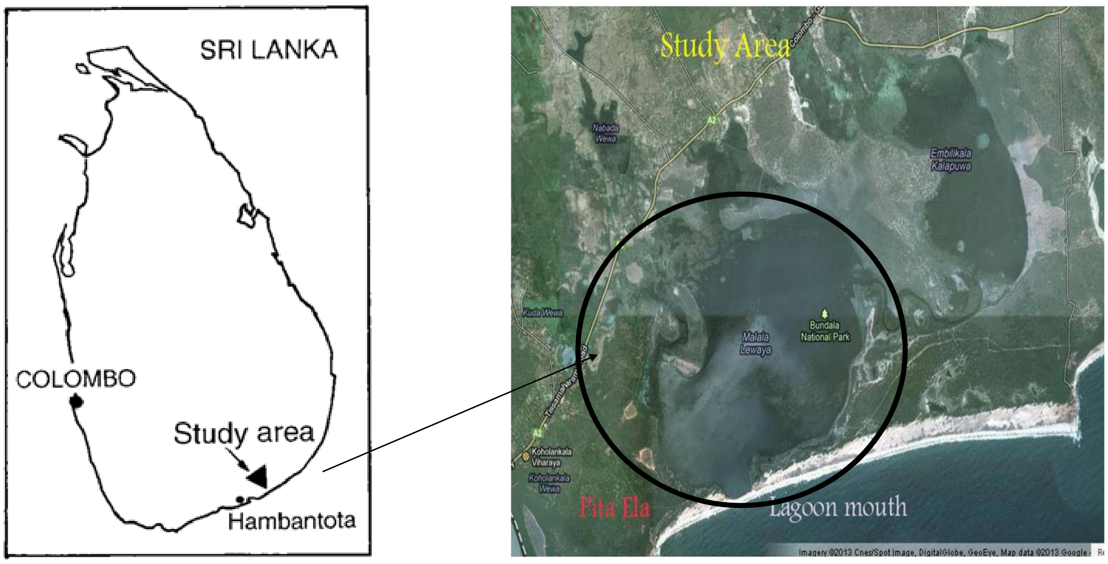


Figure 1: Study area

Decreased salinity in the Malala-Embilikala lagoon water and inundation of riparian land have caused severe socio-economic problems to the people who rely on the lagoon resources for livelihoods and also farmers who carry out their agricultural activities in the periphery of the lagoon. Therefore, an effort was made to find the vulnerable area and vulnerable communities to the flood; to carry out a scientific study to assess the hydrological, ecological, and biological impacts of the increased inflow into the lagoon; to study how the above problems affect the fishing community who depend on the lagoon for their livelihood , the farmers community who rely on paddy fields of vulnerable area and the other organisms who depend on the lagoon and surrounding area for their livelihoods; to find a long term solution acceptable to farmers, fishermen and the Bundala wildlife authority as both Malala and Embilikala lagoons are situated inside the Bundala conservation area.

Methodology

Data were collected by using a questionnaire from the villagers and by interviewing the Grama Niladari of Koholankala. No. of 14 farmers of the Udamalala Shakthi farmer association were interviewed and questionnaires were filled accordingly. Information about the fishermen was filled according to the gathered data from the fisheries cooperation of Udamalala. Secondary data were collected by interviewing the Grama Niladari of Koholankala G.N. division, Assistant Director of Hambantota Disaster Management Coordinating Unit and Director of Statistical Branch and the field officers of Bundala National Park.

Hazard Factor Area(HF_A) was calculated using following equation (Matsuno *et.al.,*1998).

$$HF_A(i) = \frac{\text{Area under flood in land unit i}}{\text{Total area of land unit i}} \times 100$$

Results and Discussion

The study area was affected by the flood and the area which could be survived after the flood (fig 2). In the village Udamalala of Koholankala G.N. division, from total paddy cultivation area of 49.5 acres 35.25 acres of land was inundated from the last flood event and it was 71% of the total land area and only 14.25 acres (29%) of land area was under survival condition after the flood.

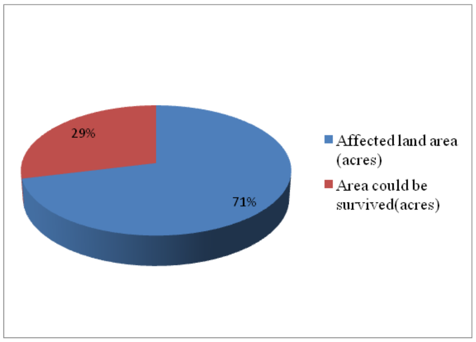
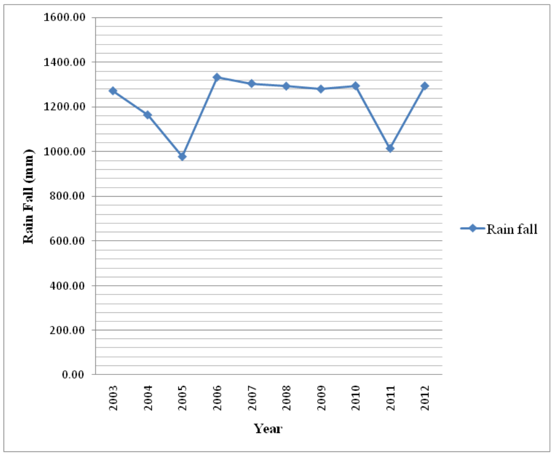


Figure 2: Percentage of affected paddy lands and lands under survival.

According to the Shakthi farmer association of Udamalala, about 200 acres of paddy fields of all four G.N divisions (Koholankala, Pallemalala, Boralessa, Bundala) are flooded during the rainy season as the lagoon water does not flush away. Therefore, they had taken immediate decisions to breach the sand bar to open up the lagoon for the water to flush out, not only once but thrice in 2006/2007 and four times from 2012 November to 2013 January (Source: District Disaster Management Coordinating Unit, Hambantota) during the cultivating season.

The sand bar opened 18th December 2012 due to the flood itself without any human interactions. This inundating water takes more than 4 or 5 days to sweep away from the paddy fields even after cut off the sand bar. This created severe economic problems for the farmers who rely on these paddy fields for their livelihoods. Many farmers had taken loans from private banks to their paddy fields and after the flood they were affected severely. After the flood as the land was mixed with saline water, if they want to cultivate again they should prepare the land for that by reducing the level of salinity to be suitable for the paddy. This situation affects the farmers not only economically but also physically and mentally.

Fig. 3(a) shows the rainfall distribution of Hambantota district from 2003-2012 and it was observed that the annual rainfall was increased up to 1330 mm after 2005 and again the rainfall decreased in 2011 to about 1000 mm and then in 2012 it was increased to 1290 mm. It was observed in fig 3(b) that the rainfall from the month August to December had been increased rather than in the other months. In October, November and December the rainfall was very much higher and according to the farmer organization of Udamalala, they cut open the sand barrier in these periods more than 2-3 times.



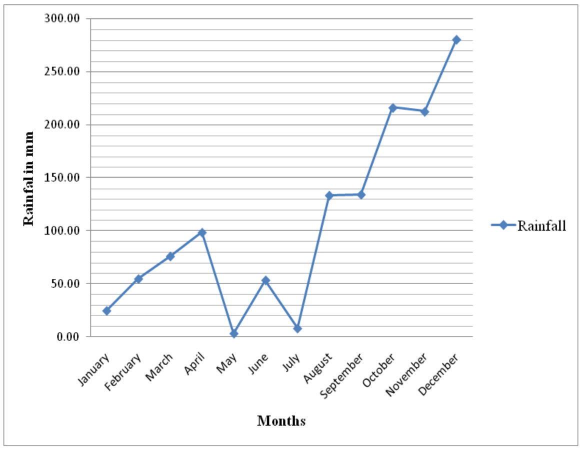


Figure 3: (a) Annual rainfall distribution of Hambantota district from 2003-2012, (b) Monthly rainfall in Hambantota district in 2012

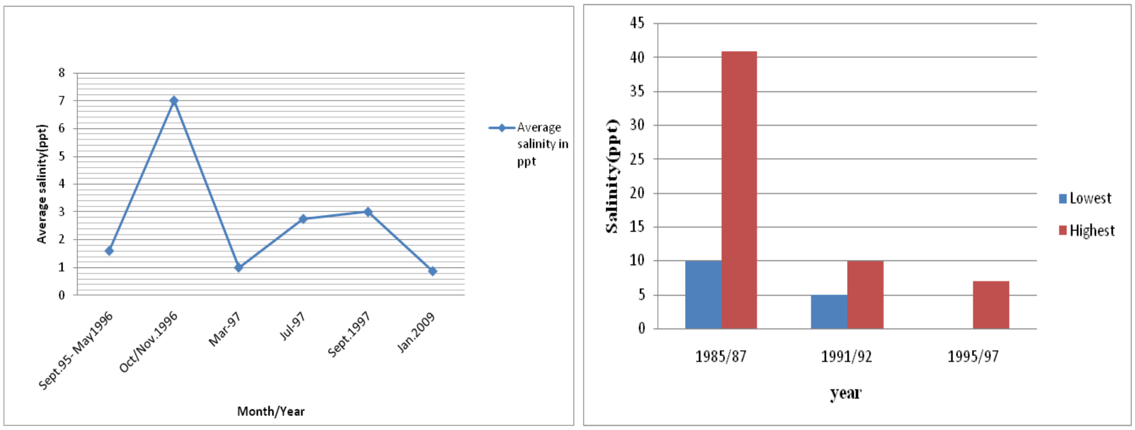


Figure 4: (a) Average salinity of the Malala lagoon from 1996 to 2009, (b) Highest and lowest salinity levels in the Malala lagoon from 1985 to 1997

The drainage of irrigation from the Lunugamwehera project that was commissioned in 1986 and the Bandagiriya Irrigation Scheme located upstream of the lagoon system, have adversely affected water quality in Malala and Embilikala lagoons (Priyadarshana et.al.,2009). Salinity levels have dropped due to the increase fresh water inflow into the lagoons. There is a concern is that further increases in fresh water input to the lagoons would render them unsuitable to existing aquatic species(Matsuno et al. 1998). One of the major impacts of irrigation water could be the raising of water levels in the lagoons that could make feeding sites unavailable for many water birds. Also, the increased fresh water inputs to the lagoons may effectively convert these rare brackish coastal ecosystems into fresh water ones and have a profound impact on the associated biota.

Water quality changes show that the salinity levels were decreasing in the lagoon. It was observed that the salinity in the lagoon has been dropped below 1ppt in 2009 (fig. 4a). Fig. 4(b) illustrates the highest and lowest salinity levels of the lagoon from 1985 to 1997. It is observed that in 1995/1997 the lowest salinity level was dropped to zero and the highest salinity level was 7 ppt which was lower than the lowest salinity in 1985/1987. With time both the highest and the lowest salinity levels were decreased very rapidly. From tables 1, 2 and 3, a large number of species which cannot tolerate fluctuations of salinity to such low levels have disappeared from the lagoon. Instead several new species were found in the lagoon after this water quality alteration. Yet, a number of species have showed resilience even after decreased salinity. It has been observed the species have declined in the lagoon as a result of decreased salinity levels, and all these species as listed in table 2, are economically very important for the fishermen.

Most important species in the decline is *Metapenaeus* and *Penaeus* species (Fisheries Cooperation, Pallemalala), which fetch higher prices at the market. On the other hand, the abundance of species like *Anguilla bicolor* which have shown resistance to salinity changes has increased which do not have a demand markets, and hence considered useless. As per the fishermen in the surrounding area who rely on fishing, in present, comparing to the past fish catches, it has been decreased the amount of fish production in the lagoons. And also after sometime in future they may be lost the fishing site for varieties of fishes, and these lagoons may convert into a livelihood for fresh water species which are shown in table 3.

The average fish production has dropped from more than 120 kg/ha (before 1992) to less than 50 kg/ha based on the information provided by the fisheries cooperation of the area. Shrimp production, which was the lucrative and thriving activity of the fishers have declined to negligible levels at present from 15-30 kg/ha before 1986/87. Decreasing fish catch has led the fishermen to employ sub optimal practices. Decreasing income has forced the fishermen to devote more time in fishing even juvenile and young cohorts, which have pushed the yields to go below marginal levels and unsustainable. At least, 75% of the fishermen in the area are affected badly due to this loss of livelihood.

Table 1: Species that showed resilience to low salinity levels (Source: Bundala National Park)

Species	**Local name**	**1991/92**	**1993/95**	**1995/97**	**2009**
Anguilla bicolor	Aandha	√	√	√	√
Arius maculates	Anguluwa	√	√	√	√
Chanos chanos	Vaikkaya	√	√	√	√
Gerres filamentosus	Olaya		√	√	√
Mugil cephalus	Serayawa	√	√	√	√
Terapon theraps	Keeli		√	√	√
Oreochromis mossambicus	Tilapia	√	√	√	√
Oreochromis niloticus niloticus	Nilotica		√	√	√

Although it is a positive effect for the growth of fresh water species, the problem is the lost of varieties of saline water species in the lagoons. And also for the fresh water species there are several breeding sites available in the country but for these saline water species there are only limited sites available. So this problem has to be solved as quickly as possible to protect these natural resources.

Table 2: Species which were lost after decreased salinity levels (Source: Bundala National Park)

Species	**Local name**	**1991/92**	**1993/95**	**1995/97**	**2009**
Caranx sexfasciatus	Inguru parava	√	√		
Ambassis ambassis	Katilla	√	√		
Glossogobius giuris	Weligowwa	√			
Hyporhamphus limbatus	Morella	√			
Metapenaeus sp.	Eian issa	√			
Opisthopterus tardoore	Maisthre lagga	√			
Penaeus indicus	Kiri issa	√			
Penaeus merguiensis	Kiri issa	√			
Penaeus monodon	Karawadu issa	√			
Tetraodon fluviatilis	Bataya	√			
Thryssa setirostris	Laagga	√			

Table 3: New species found in the lagoon (Source: Bundala National Park)

Species	**Local name**	**1991/92**	**1993/95**	**1995/97**	**2009**
Alectis ciliaris	Kaha parava			√	√
Etroplus suratensis	Koraliya			√	√
Labeo dussumieri	Hirikanaya			√	√
Liza vaigeinsis	Godaya			√	√

There are positive consequences due to these physical changes that take place in the water body such as creation of new habitats, expansion of wetlands to land-water interface, supporting diverse biological communities due to expansion of habitats etc. However, it is apparent that drastic ecosystem changes are taking place due to changes in water levels: a number of large trees have died in the recent years at inundated areas. Loss of large vegetation canopies will affect nesting habitats of larger bird species and there is a danger of diminishing populations of large migrant birds from this wetland site (Table 4). It is apparent that large patches of *katu andara*, although an alien invasive species, have died; however, the effect of this is yet to be seen. Eradication of such invasive species (according to villagers, it has become a nuisance to both human and wild animals, too) might have positive impacts on the ecosystem.

The ecosystem of the Malala – Embilikala lagoons have been severely affected by the drainage flow from the KOISP (Kirindi Oya Irrigation and Settlement Project) and the Bandagirya irrigation schemes. Since the KOISP was implemented, the salinity of the lagoons has dropped due to the inflow of upstream irrigation water. This change in salinity levels has influenced the population of birds as it has affected their food supply. Fortunately for the past ten consecutive years tracts 5, 6 and 7 have only been cultivated in one season due to the water shortages in the scheme (De Alwis et. al., 2008), which has positively affected the Embilikala lagoon.

As per the Bundala National Park the runoff released from the both KOISP and Bandagiriya which reach the lagoon system are high nutrient pollutants due to the agricultural based activities. The water brings in high amounts of nutrients (breaking the phosphorus limitation barrier) into the lagoon system, which is evident from high productivity and eutrophication which is an emerging problem in the lagoons (Abeywickrama, 2009). The water is being greenish colour as a result of the accumulation of nutrients and increase green algae. The main causes are overgrazing which results in animal faeces entering surface water and runoff from upstream irrigated areas, which brings fertilizer and soil into the lagoon, as well as other agro chemicals including insecticides, herbicides and fungicides, especially as these chemicals are sometimes applied in excess of agricultural requirements. Lush growth of higher forms of aquatic flora has reached uncontrollable levels. Although water quality records are unavailable, it is suspected that agrochemical and their residues have contaminated the lagoon. One piece of evidence to support this was the fishermen's claims that they have noticed skin rashes, and irritations when in contact with lagoon water for prolonged duration. Agro- chemicals are toxic to birds and aquatic life. Also bioaccumulation of any of these chemicals will have impact on humans who consume such aquatic produce. The increased growth of aquatic plants leaves the current methods of fishing difficult to carry out. This can lead to less catch or fishers trying to remove plants causing them extra stresses.

Table 4: Types of vegetation commonly found in the area

Species	Local name	Type of vegetation
Acacia chundra		Tree
Acacia eburnea	Kukul katu	Shrub
Atalantia ceylanica	Yakinaran	Shrub
Aquilaria agolocha	Agil	Tree
Azema tetracantha	Masbadda	Shrub
Blachia umbellate	Kossatta	Shrub
Cassia auriculata	Ranawara	Shrub
Dichrostachys cinerea	Andara	Shrub
Drypetes sepiaria	Weera	Tree
Manilkara hexandra	Palu	Tree
Opuntia dellenii	Pathok	Shrub
Prosopis juliflora	Mesquite	
Salvadora persica	Mallithan	Tree
Securinega leucopyrus	Katupila	Shrub
Tetrameles nudiflora	Hema	Tree
Terminalia arjuna	Kumbuk	Tree

Modifications of the irrigation system in the recent past has been altered the hydrology of the area. The inundation and subsidence and draw down of the water levels have subsequently created sedimentation problems in the lagoon (Smakhtin et.al., 2002). The flood water carries large amounts of fine sediments from the riparian areas, and gets deposited in the lagoon. Under the resettlement programmes and agricultural development activities in the catchment, large extent of forest clearing and direct runoff to the lagoon system have increased. Due to the both hydrological changes and development activities, the inputs of sediment have increased dramatically. As the flushing out of the lagoon does not take place frequently, this deposited sediment (the muddy layer at the bottom) has grown into layers thicker than previously observed levels. This has been threatening the ecology of the water environment, affecting both flora and fauna.

And as per the Bundala National Park the problem of sedimentation is increasing at a higher speed and most of the lagoon area was covered by mud. If this situation will not be controlled, in future the whole lagoon system will disappear. As mentioned in previous sections, both lagoons drain into the sea through a small outlet. This natural outlet is covered with a very wide (50-70m) sand bar which has to be breached manually or has to remain until the lagoon water level rises high enough to wash the sand bar away. In order to alleviate this problem, a canal has been excavated in 1994 (Abeywickrama, 2009). It is about 16m wide and runs about for 1 km until it reaches a rocky beach with insufficient sand movement to block the outlet. At present there is a water level-regulating structure at the lagoon end of the canal (i.e. upstream end of the canal). This structure has 10 bays with provisions to insert timber planks with a span of 1.6 m each. Particular tail section adopted in the construction has reduced the effective canal bed width to about 10 m which otherwise would be about 16 m. in an average day in a rainy season with no floods, flow through this structure is about .2 to .5 m^3/s. with the arrival of the flood, when the water level goes up, flow speed picks-up. In the absence of any backwater effect from the sea water levels, discharge capacity of a 16 m wide canal with about 1.5 m water depth will be about $50m^3/s$. Therefore this canal can carry a maximum of about 4.3 MCM of water in to the sea in 24 hours.

Present water surface area of Malala and Embilikala lagoons during an average day with no flood situation is about 1000 ha. During flood, water surface area may increase by about an additional 300 ha (District Engineers Office, Hambantota).

Conclusion

An acceptable solution should consistently satisfy the safeguard of the fishing community, protect the agricultural land from unwanted inundation with lagoon water, not disturb/disrupt the delicate balance between anthropogenic activities and biology/ecology of the lagoon system and should be able to promote /maintain ecological health of the wetland ecosystem as a whole. When concern about the fishing community, to reduce the inflow into the lagoon; so that salinity of the lagoon water is favorable and support enhanced fishery activity, thereby reviving their lost livelihoods to become economically stable. If there is no way to achieve reduces water inflows, then to find a feasible solution to maintain the fish population at sustainable levels while maintaining a sufficient water level. When concern about the farming community, to carry out farming and related activities without any disturbance and interruption is recommended.

At present, the farmers are able to cultivate only two seasons, and they are forced to harvest before the rainy season to avoid flooding of the land due to increased lagoon water levels. This has created various difficulties for them, as they are in constant ambiguity and confusion as to what would happen during the cultivated season: whether the field would go under water or not.

They also say that unlike fishermen, the farmers have to invest capita; and running costs for agricultural activities. On the contrary, the fishermen do not have to invest any money in cultivating fish in the lagoon and they spend only labour and time for returns. Once the farmland is inundated and consequently when the harvest is destroyed, the farmers loose both their investment as well as the livelihood. The farmers' attitudes towards the fishing community are very hostile and unfriendly due to the above reason. Under these circumstances, the farmer community resorts to inflexible and hasty action of breaching the sand dune, which is detrimental to maintaining fish stocks in the lagoon which is not acceptable to the fishing community.

The farmers suggest that the solution for increased water level is to allow breaching of the sand dune, when the water level reaches a predetermined datum. But this solution would not acceptable by fishing community. For that reason the objective of this study is to explore whether a datum can be established to maintain the lagoon water at level that is acceptable by both the communities.

Subsequently, the second task would be exploring how to achieve and maintain this water level. The method of maintaining the water level is crucial to fishing communities and thus must be acceptable to them. It is important because the farmer might not be interested in how to achieve this, and at the same time it would be difficult to reach a compromise unless they are convinced that the solution proposed has consistency in maintaining the water level.

Finding a technical solution:

Five alternative solutions were considered for the problem and they were compared with each other economically and environmentally. Then finally the best alternative was selected as the most suitable solution for the identified problem.

- Constructing a concert spillway at the location where the sand bar is formed, thereby allowing the water to spill over to the sea when the water level rises.
- To make an anicut across the Ooday connecting the Embilikala and Malala lagoon.
- To divert water from Embilikala lagoon directing to sea through a cannel constructed towards Bundala Lewaya.
- To rehabilitate and modify the existing canal of Pita Ela located at south west end of the lagoon, to augment its capacity of flow thereby allowing continuous flushing out of excess water.
- To divert the access inflow from the development programmes (KOISP and Lunugamwehera projects) through a new canal to the sea through the reserved area of Bundala National Park. This can be constructed in between Malala lagoon and the Koholankala lagoon.

Table 5: Comparison of the alternatives

Alternative	Cost	Environmental impact
1. Canal from Embilikala lagoon to the sea.	High	Negative
2. Concrete spillway at the sand bar.	Extremely high	Negative
3. Anicut across the canal.	High	Negative
4. Modification of the outlet canal.	Low	Not significant
5. Divert water directly to the sea from a canal through the reserved area.	High	Positive

Considering the cost and the environment impact, Alternative 4&5 are seem to be feasible (table 5). From these two alternatives if considered only about the cost and the affected communities the alternative 4 is most suitable but, when considered about the species living in and around the lagoon, the alternative 4 is not an acceptable solution. Because modifying the outlet canal will reduce the water level in a flood situation and it will always act to carry out access water in the lagoon to the sea. So that the lagoon water will never be mix with the sea water, then lagoon water will become more and more fresh and finally will become completely a fresh water lagoon. This will create severe problems to the species living in and around the lagoon which rely on saline water.

Considering the biological environment and the inundation affects the alternative 5 is the best alternative to be acceptable by both the communities and the environment.

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